ARS SPECIAL REPORT

HOJA BLANCA
Serious Threat to Rice Crops

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SUMMARY

This Special Report has been written to bring together in brief what is currently known about hoja blanca disease, and the present status of research, survey, and eradication efforts to combat it. The report is supplied to agricultural leaders to serve as a basis for answering routine queries about the disease, and for developing educational programs in support of preventive, control, or eradication measures by farmers.

Information in this report was provided by the Crops Research Division, Entomology Research Division, and Plant Pest Control Division, Agricultural Research Service.

HOJA BLANCA, SERIOUS THREAT TO RICE CROPS

Hoja blanca (meaning white leaf in Spanish, and pronounced o-ha-blan-ka) is a relatively new disease of rice plants, now posing a formidable threat to the United States' $225 million a year rice crop.

In 1959, this virus disease launched its first direct attack in one of our major rice-growing areas--in Louisiana. The insect that spreads the disease was found by Federal-State surveys in 14 Louisiana parishes, and the disease itself in rice plants in 11 of these parishes.

Although eradication work was prompt and the season ended without real economic loss, this outcome is not reassurance. In the experience of two Latin American countries--Cuba and Venezuela--an initial outbreak of hoja blanca has foreshadowed heavy rice crop losses in following years. Awaiting the development of resistant new rice varieties, many growers in these countries have had to abandon their preferred varieties, mainly American long-grain rice types, and plant a few stopgap medium-grain varieties known to have some resistance.

Hoja blanca has been spreading in tropical America since 1952 and is one of the most troublesome problems that rice growers in the Western Hemisphere have had to face. If the disease proves able to flourish in our temperate zone and under our farming conditions, as it can in the tropics, it will be a threat to our commercial rice belts--the concentrated rice plantings covering 1,500,000 acres in Louisiana, Arkansas, Mississippi, Texas, and California. All leading rice varieties grown in these States are known to be susceptible to hoja blanca.

Intensive efforts to understand and control hoja blanca represent cooperation between the Agricultural Research Service of the U. S. Department of Agriculture, agricultural agencies in affected States and Latin American countries, and the rice industry.

It is important that growers and others concerned in the rice industry have up-to-date information as preparedness for dealing with this disease on a short- or long-term basis, where emergency arises.

HOW THE THREAT HAS SPREAD

Hoja blanca has been identified only in the Western Hemisphere. It appears to be a rice plant disease native to the western world.

When hoja blanca attracted attention in Panama in 1952, the small infestations did not show immediately how destructive the disease could be.

By 1956, hoja blanca had demonstrated that it could spread swiftly and wreck rice production. That year, growers in Cuba lost 25 percent of their crop; and in Venezuela, more than 50 percent. In Venezuela, the disease spread through the entire rice-growing area of 75,000 acres in 90 days after its discovery. Latin American countries where hoja blanca has appeared are shown in figure 1, with date of discovery indicated.

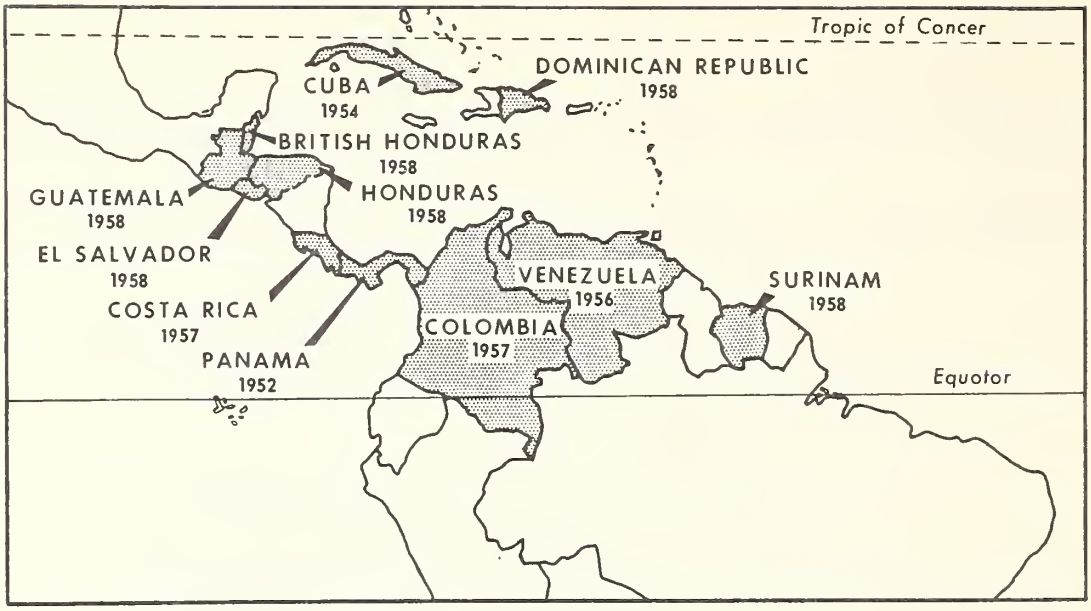

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Figure 1.--This mop shows where hojo blanco hos oppeored in tropicol Americo since the diseose become o threot to rice in 1952. The yeors of discovery ore indicoted. The vector, but not the diseose, hos been identified in Puerto Rico, British Guiono, Argentino, ond Mexico. The diseose hos been reported, but not identified, in Mexico, Ecuodor, ond Nicoroguo. Since the diseose wos found in Colombio in 1957, o plont pothologist of thot country hos stoted thot the some domoge symptoms hove been observed there since 1935. The insect vector hos o still eorlier history. It wos clossified ond nomed Sogoto orizicolo Muir in 1926 from o specimen collected in British Guiono.

Since the autumn of 1957, the hoja blanca virus and its insect vector have invaded three of our Southern States--perhaps due to the insect riding winds in a tropical storm. The dates and locations of these outbreaks are listed in table 1.

Table 1.--Hoja blanca and/or its insect vector in the United States to November 30, 1959.

State	County or parish	Year	Properties
Florida	Palm Beach (Belle Glade)	1957	3
	Palm Beach (Belle Glade)	1958	2[1]
	Palm Beach (Belle Glade)	1959	2[1]
Mississippi	Hancock (Bay St. Louis)	1958	2
	Harrison	1959	1
Louisiana	Ascension, Assumption, Evangeline, Iberville, Lafourche, Madison, St. James, St. John the Baptist, St. Landry, St. Martin, St. Mary, St. Tammany, Terrebonne	1959	34

[1] Same properties as in 1957.

Source: Plant Pest Control Division data, unpublished.

The outbreak of hoja blanca in Florida was hundreds of miles from major rice-growing country. The outbreak in Mississippi was closer to a commercial rice area but still marginal. The outbreak in Louisiana intensified the economic threat by its direct attack in a rice belt.

It is not certain whether the recurrences represent separate invasions of the insect vector or survival of the disease through incomplete eradication of the vector.

HOW HOJA BLANCA IS BEING FOUGHT BY RESEARCH

In 1956, when hoja blanca gave clear warning of its destructiveness, ARS joined with Latin American agencies on an emergency program focused on three objectives:

1. To understand the nature of the disease and how it can be transmitted--for clues to control.

2. To determine the biology, ecology, and control of the vector.

3. To provide growers with rice varieties that combine resistance and desirable qualities--the best hope for protection.

Much of the United States' work thus far has been done in Cuba, Venezuela, and Colombia, where research on the disease has been active and the reaction of breeding lines could be studied under field conditions. Early in 1960, the two entomologists and the plant pathologist assigned to the ARS Hoja Blanca Laboratory in Cuba transferred to the Louisiana Agricultural Experiment Station in Baton Rouge to study the disease and its vector in our Gulf Coast climate.

Learning About the Disease

Two Terms in Practical Use

The causative agent of the hoja blanca disease is now commonly termed the virus. A plant hopper (Sogata orizicola Muir) is commonly termed the vector. These terms suit convenience and are reasonably accurate.

Actually, a virus has not been isolated and used in producing hoja blanca in rice plants--which would conclusively identify a virus as the cause. However, hoja blanca is so similar to other virus-caused diseases in plants that a virus is almost certainly the hoja blanca causative agent.

As for the vector, the plant hopper S. orizicola has been the only insect proved responsible for transmitting hoja blanca, and numerous other suspect insects have been tested and ruled out. Additional insects, however, continue to be tested.

What Happens to Infected Rice Plants

The symptoms and damage to expect when rice plantings are infected by hoja blanca are now mainly clear.

Rice plants at all ages are susceptible, but the damage in young plants is of most concern for these combined reasons:

- The younger the plant when infected, the poorer its grain production. Very young plants may be killed outright.

- Tender young rice plants are targets sought out and preferred by the hopper for feeding and egg-laying.

Hoja blanca symptoms have been known to appear in young rice plants as early as 5 days after the hopper began feeding, although a lag of 2 weeks is more usual.

The first signs of hoja blanca infection are yellowish-white spots or streaks on some emerging leaves, indicating loss of vital green chlorophyll. An emerging leaf may at first show a few spots, and the part appearing later may be nearly or completely white. Once a leaf has developed, the symptoms may sharpen with age but the pattern will not change: That is, a leaf partly streaked or mottled will not whiten more extensively. The damage in a plant as a whole is likely to be progressive, with succeeding leaves that appear showing increasingly serious symptoms.

A plant infected when young fails to grow to normal height. Florets are brownish and deformed. Panicles (heads) of the diseased plants remain upright instead of drooping in normal fashion. Ultimately, the heads produce few or no seeds. The contrast between a drooping, grain-laden rice plant and a stunted unproductive plant damaged by hoja blanca is pictured on the map in figure 2 (page 12).

In recent field tests in Cuba, ARS scientists measured the loss in panicle weight when susceptible varieties of rice were infected at various ages by hoja blanca. The younger the plant when infected, the greater was the yield loss. Losses ranged from 386 to 1,158 pounds per acre in fields that normally yield about 3,000. Total losses after milling would be even more staggering.

A rice plant once infected with hoja blanca is never entirely freed of the virus. When such plants put out new tillers after the primary harvest, the ratoon crop may develop badly or well, depending on the amount of the virus remaining. Some new shoots on the same plant may be diseased and some healthy.

Hoja Blanca Distinguished from Stripe

Plant scientists who first examined hoja blanca damage in rice plants recognized a strong resemblance to stripe--a rice disease never known to cause economic damage outside of Japan, and not known to occur in the Western Hemisphere.

Stripe is a "yellows" disease, caused by a virus, carried by a plant hopper--all true of hoja blanca. It seemed possible that stripe might have reached Latin America.

But experiments have proved that different plant hoppers carry the two diseases, indicating that the viruses have different requirements and are therefore not the same. Experiments have shown also that rice varieties react differently to the two diseases: That is, a variety may be resistant to hoja blanca and susceptible to stripe.

Moreover, plant symptoms of hoja blanca and stripe, although similar, can be distinguished. Japanese scientists who visited Cuba have pointed out that leaves of an hoja blanca-damaged plant develop normally except for the characteristic whitening; whereas the central leaves of a stripe-damaged plant fail to unroll and tend to bend down in the shape of a sickle-blade. The Japanese scientists commented that hoja blanca does not kill young rice plants as extensively as does stripe. This difference may be explained, at least partly, by the fact that S. orizicola infestations have been light early in a season, with a build up toward heavy populations as the season advanced.

The Key Role of the Hopper

The hoja blanca virus can destroy rice plants only when the right insect provides essential incubation, transport, and transmission into rice plant tissues. Without the insect, various experiments to produce the disease in plants have failed. Scientists have tried inoculating healthy rice plants with juices from plants infected with hoja blanca, growing rice plants from seed of infected plants, and planting in soil in which infected rice plants have grown--all without developing hoja blanca in test plants. On the other hand, they have successfully inoculated rice plants by using the hopper S. orizicola as a vector. Destroying or outwitting this insect, therefore, is a main key to control of the disease.

The hopper responsible was a relatively unknown insect when it was identified as the hoja blanca vector in 1957. Almost all of the following information about this insect's life cycle and habits has been obtained by research and observation since it became a recognized pest.

The female adult hopper in her lifetime lays about 160 tiny, white, slightly curved eggs in midribs of rice leaves.

In 8 to 11 days, newly hatched nymphs appear on the leaf blades and start feeding. The nymphs go through five stages, each lasting about 3 days, and as they grow older they turn brown and move to the emerging leaf. In tropical countries, the period from egg to adult lengthens from about 3 weeks in summer, when temperatures average around 80° F., to more than 5 weeks in winter, when temperatures average about 10 degrees lower.

The adult, about one-sixth inch in length, includes long- and short-winged forms, and some females are wingless. The adult male lives an average of 25 days, the female 34.

The insect feeds rather low on the plant, which tends to make it inconspicuous unless the population is dense. Despite its "hopper" name, the insect is not an active jumper or flier. When disturbed, the male flies to another plant; the female tends to drop or fly down to the ground or water. Heavy winds and flowing water help to spread the small pest.

The insect can harbor the hoja blanca virus at all stages of its life cycle, including the egg. Both nymphs and adults can transmit the virus to rice plants.

After taking up the hoja blanca virus from juices of a diseased plant, the vector must incubate the virus for at least 6 days before it can infect another plant.

Experiments have indicated that less than 10 percent of a population of this hopper is capable of transmitting hoja blanca. Even this seemingly low proportion of carriers in a heavy population is enough to cause tremendous destruction.

In Cuba, the hoppers are fewest in winter and less damaging to rice that is seeded in November, December, or January than to the same varieties seeded in spring. Seeding early in spring for an early harvest presumably would give temperate zone rice growers some advantage over the insect.

The hopper is known to require warmth, along with high humidity, for its survival and increase. There is some information on limits of heat and cold it can stand. ARS entomologists in Cuba found that both nymphs and adults of the hopper died when subjected experimentally to heat of 107° F. for 12 hours. Because of the complete mortality at this temperature, they believe that temperatures a few degrees lower than this may be lethal. These findings suggest that a heat wave in our rice belt climates might slacken the increase of a hopper horde. Our heat waves exceed heat in Cuba and Venezuela, where the temperatures seldom go above 100° F.

Even moderate cold also is lethal to the hopper. In preliminary tests of its cold-hardiness, USDA entomologists exposed eggs, nymphs, and adults to the range of temperatures of a refrigerator, from -12° F. to 48° F., for 24 hours. At 48° F., all forms survived. At 20° F., all nymphs and adults were killed. At 21.1° F. 8 percent of nymphs and adults survived. At 43° F. all eggs were killed. Such tests, though, informative, have left uncertainty as to whether the hopper can overwinter in our South in one or more of its cycle stages.

Host Plants Suspected of Harboring the Virus

The hopper that carries hoja blanca strongly prefers the rice plant as its host, and rice appears to be the only economic crop it seriously endangers. However, in many infested areas observers have noted other grasses near hoja blanca-damaged rice that bore strikingly similar symptoms in their leaves and flower heads.

The numerous grassy weeds that appear to be emergency host plants to hoja blanca are being tested, on suspicion that one or more of them may contribute to the economic damage of hoja blanca in rice. To endanger rice, a weed would need to be capable of serving as a host plant both to the virus and to an insect that can transmit the virus to rice plants.

This phase of the disease involves complex investigations. Recent studies, such as the two briefly cited below, indicate a start toward understanding.

In experiments in Colombia by Rockefeller Foundation workers, the hopper vector of hoja blanca demonstrated that it could transmit the disease from infected rice plants to a selected kind of healthy grass: barnyard grass. But the hopper showed no capacity for reverse action. That is, it failed to transmit the disease from the infected grass to healthy rice plants.

ARS scientists recently tested the possibility that small-grain crops grown in rice areas of this country could serve as host plants for the hoja blanca vector and thereby provide reservoirs of infection for perpetuating and spreading the disease in rice. In these tests, they caged five male and five female hoppers for 10 days with two plants of each selected grain. The plants comprised a selected variety each of oats, rye, wheat, and barley, and one rice variety susceptible to hoja blanca. The insects showed marked preference for the rice plants and laid 210 eggs on rice, compared with 136 on rye and less than 20 on any of the other host plants. In small cage conditions, eggs laid on rice and rye hatched out and the nymphs developed into adults, showing that the hopper can complete its life cycle on rye. Furthermore, the hopper transmitted hoja blanca from rye to rice. So few eggs were laid on the other grains that little could be learned about the capability of the hopper to use these grains for completing its life cycle. These preliminary findings might not be duplicated with other varieties of grains or in field conditions, but thus far the small grains would not appear to be important hosts for this rice disease.

Providing Growers With Resistant Rice Varieties

If U. S. rice growers find need to plant varieties that resist hoja blanca, they will be in somewhat stronger position than were Latin American growers who faced this problem after losses of 1956.

A few of the less widely grown varieties are resistant, and can be grown more widely if need be. These are: Colusa, a short-grain variety commercially grown in California, and Asahi, also short-grain; Lacrosse, Missouri R-500, and Arkrose, three medium-grain varieties grown to some extent in the Southern area.

In addition to these, Gulfrose a new medium-grain type, with built-in resistance to hoja blanca, has been developed in Texas. Seed have been made available for increased production in 1960, so that seed growers will have market stocks for farmers in 1961.

Meanwhile, there is no long-grain variety with resistance and good commercial qualities yet available. But the prospect for this type draws nearer, as breeders work with promising crosses.

The World's Rice Lines Tested

Active progress in the search for resistance began in the spring of 1957 with a rapid resistance-testing of the entire USDA World Rice Collection. Cooperating with Cuba and Venezuela, ARS scientists planted more than 4,000 different lines of rice in field plots where hoja blanca was epidemic.

By the end of 1957, the susceptibility of U. S. commercial varieties was well tested. Also, the world's resources for breeding hoja blanca-resistant rice varieties were mostly rounded up. Additional tests have confirmed the main findings and added some breeding material. The significant facts are these:

All U. S. long-grain rice varieties, which form 71 percent of the South's crop, are susceptible to hoja blanca.

All medium- and short-grain varieties widely grown in the United States are susceptible, including the popular Caloro, Zenith, Magnolia, and Nato.

As breeding prospects, the 1957 tests turned up nearly 300 short- and medium-grain stocks with appreciable resistance. These were mostly from Asia. The most resistant were short-grain types.

A very few long-grain stocks from Cuba, India, Iran, and Peru showed some resistance. However, the most resistant were not suitable for our mechanized production because of weak straw or other undesirable characteristics.

Breeding Resistant Varieties

Resistance as a genetic characteristic is not difficult to transfer from one variety of rice to another. The main problem in providing new rice varieties for an hoja blanca emergency is to have them ready as fast as possible. Progeny of promising hybrids--selected from crosses made to combine hoja blanca resistance with desirable qualities--must be tested through as many as ten generations. Tests include those for straw strength, seedling vigor, yield, milling and cooking qualities, and other characteristics essential to a dependably good commercial variety.

To bring a successful cross through these stages takes 8 years or longer in our temperate zone conditions. The production of hoja blanca-resistant varieties is being speeded by two short-cuts:

1. By doing part of the testing in the tropics where two annual crops can be grown to our one crop.

2. By finding hoja blanca resistance in experimental varieties already partly developed.

These short-cuts account for Gulfrose, the first resistant variety, being ready for growers within 3 years after hoja blanca breeding work started. Work on this variety began in 1953 with a cross between a pedigreed selection from Bruinmissie and Zenith, both medium-grain rice types. The variety was developed at the Beaumont Rice-Pasture Experiment Station by the Texas Agricultural Experiment Station in cooperation with the ARS Crops Research Division and the Texas Rice Improvement Association. Bruinmissie endows this hybrid with its high resistance to hoja blanca, which was demonstrated by nursery plantings in Colombia, Costa Rica, Cuba, El Salvador, and Venezuela, and by field scale plantings also in the two countries last named.

Gulfrose as tested ranks high in qualities wanted by the producer, miller, and consumer of medium-grain rice. It is therefore a useful addition to our commercial rice varieties for the South aside from its hoja blanca resistance. Gulfrose is resistant to blast disease and only moderately susceptible to straighthead. Seeds of Gulfrose germinate rapidly and establish stands faster than other commercial varieties. The crop matures 6 days earlier than Nato or Zenith and 11 days earlier than Century Patna 231, based on experimental plot tests in Arkansas, Louisiana, and Texas. The new variety gives satisfactory yields of good quality. All plant parts, including hulls, are essentially smooth. In combining, the grains thresh from the stems easily. In processing and cooking evaluations by research agencies and industry, Gulfrose was found comparable to Blue Rose and Zenith. It appears well adapted for breakfast food and baby food manufacture.

Some years must elapse before any long-grain hoja blanca-resistant rice variety as acceptable as Gulfrose can be expected. No partly developed varieties of long-grain type offered help when breeding for hoja blanca resistance began in 1957.

To develop these long-grain varieties, USDA scientists are working cooperatively with rice experiment stations in Arkansas, California, Louisiana, and Texas. Many promising types are being obtained from the best prospects: crosses of long-grain varieties, such as Rexoro, Bluebonnet, and Century Patna, with medium-grain varieties that resist hoja blanca, such as Gulfrose, Lacrosse, and Arkrose.

Hoja blanca resistance shown by first generation hybrid plants has been well sustained after back-crossing--the process of progressively crossing hybrid generations with the original long-grain parent to strengthen its desirable commercial qualities to a maximum without losing resistance. The prospect is that a reasonably large number of promising selections will be ready for yield tests by 1961. Some testing of the breeding lines is being done by sending seed of the crosses to the tropics for continuous plantings. Cuba, Colombia, El Salvador, Venezuela, and Costa Rica are cooperating on these tests.

Building Up Seed Stock

Seed of reasonably satisfactory short- and medium-grain resistant varieties of rice are now available or could be available in a short time. The four rice experiment stations are producing these foundation seeds, and seed growers are cooperating in providing increased market supply.

In California, seed of Colusa variety is available in large quantity.

In Louisiana, there has been increased seed production of Lacrosse--consistently one of the most resistant varieties tested.

In Texas, all available seed of Gulfrose was sown in the spring of 1959, on 650 acres in 8 counties. These field tests produced about 2,000,000 pounds of foundation seed to enable growers in 1960 to produce seed for farmers by 1961. Also, 150 acres of a promising short-grain rice from Taiwan have been grown in Texas for consideration as a seed source. This variety resists hoja blanca, gives a high yield, and produces a short, sturdy straw under growing conditions in our South. It is known in Taiwan as Tainan-iku No. 487, and for the present in our country has been given the experimental designation PI 215936.

In Arkansas, a major part of the commercial Arkrose crop comprising several thousand acres could be utilized as seed, should an emergency arise.

HOW A HOJA BLANCA OUTBREAK IS FOUGHT

From the first discovery of hoja blanca in the United States, each outbreak has promptly brought to the scene Federal and State scientists to determine the extent of the infection and guide eradication work.

In 1957, when hoja blanca was first found in Florida--at the Everglades Experiment Station--the ARS joined with the Florida Agricultural Experiment Station and Plant Board to make a quick survey for signs of the disease elsewhere in southern Florida. This search showed that the disease was limited to Everglades Experiment Station plots, an adjacent rice field, and volunteer rice in a field 5 miles to the west.

This first survey was completed within 2 days, and a few days later eradication measures agreed upon by Federal-State agencies were started.

The Emergency Pattern of Action

The program for organized action in any hoja blanca outbreak calls for treating all infested fields with insecticide at weekly intervals until frost.

The same pesticides used in 1957 and in later hoja blanca outbreaks are still the best known for practical control. The insecticide used if rice is not near harvest is a water mixture of malathion and DDT applied as a spray. The area sprayed should include presently infected fields, fields where volunteer rice occurs, and borders and other places where volunteer rice may grow. In fields nearing harvest, the hoja blanca spray treatment is changed to the use of wettable powder of Phosdrin. Phosdrin can be safely used up to a few days of harvest, because its residue lasts only 1 or 2 days.

Aircraft is used for most of the hoja blanca insect control work. Ground equipment is used--to limit the spray to target plants--where

an airplane-diffused spray might contaminate water that supports wildlife. Ground and hand equipment is used for applying the herbicides.

The Continuing Search for Damage and Danger

Any locality where hoja blanca has once appeared needs to be kept under close watch because eradication methods, however thorough, may not wipe out all danger sources.

A need for more extensive scouting was recognized after Florida's first experience with the disease. Since then, Federal-State surveys of the entire rice-growing area have become a yearly practice.

How these cooperative surveys have developed and what they have accomplished is summarized briefly here.

In 1957, the initial Federal-State survey in Florida used quickly trained volunteers to help cover a large area speedily.

In 1958, to make sure that some hoppers had not spread northward and survived, several USDA and Florida plant pest control scientists made a survey trip into northern Florida in early September. They located no rice fields in northern Florida. The ARS scientists traveled on into southeastern Georgia and South Carolina, where they located a few rice fields and, reassuringly, no sign of hoja blanca.

The same month, September 1958, hoja blanca was discovered by ARS scientists in Hancock County, Miss. At their warning, a State survey was launched to search intensively for hoja blanca. No sign of the hopper or its damage was found in Mississippi beyond the two fields in Hancock County where cultivated and volunteer rice plants had been reported infested. However, Federal-State representatives took the precaution of following up with a quick, limited search in other major rice-growing Southern States. These surveys in 1958 covered 25,000 acres of rice land on 500 farms in Arkansas, Louisiana, Texas, and the Mississippi area already covered. California, meanwhile had made a State survey in 1958 in 14 counties, covering more than 3,000 acres on 139 properties. In all of this precautionary work, no trace of hoja blanca or its vector was discovered in the commercial rice-growing area beyond the small infested area in Mississippi.

In 1959, Federal-State agencies launched the first big systematic program of surveys for hoja blanca in all five of the major rice-growing States, and North and South Carolina and Florida. Regulatory and research workers carried out this search early in the summer.

The warning that hoja blanca had reached Louisiana came through this 1959 survey program. A Louisiana State survey entomologist made the first discovery--finding a number of vectors in St. Tammany Parish. This parish adjoins Hancock County, Miss., where hoja blanca had appeared in 1958 but had not recurred. This corner of Louisiana is some distance from the State's large rice plantings, but the discovery of the insect in St. Tammany in July was followed by finding the hopper in 13 more parishes, extending westward into the heart of rice-growing country. In 11 of the parishes, the disease as well as the insect was discovered.

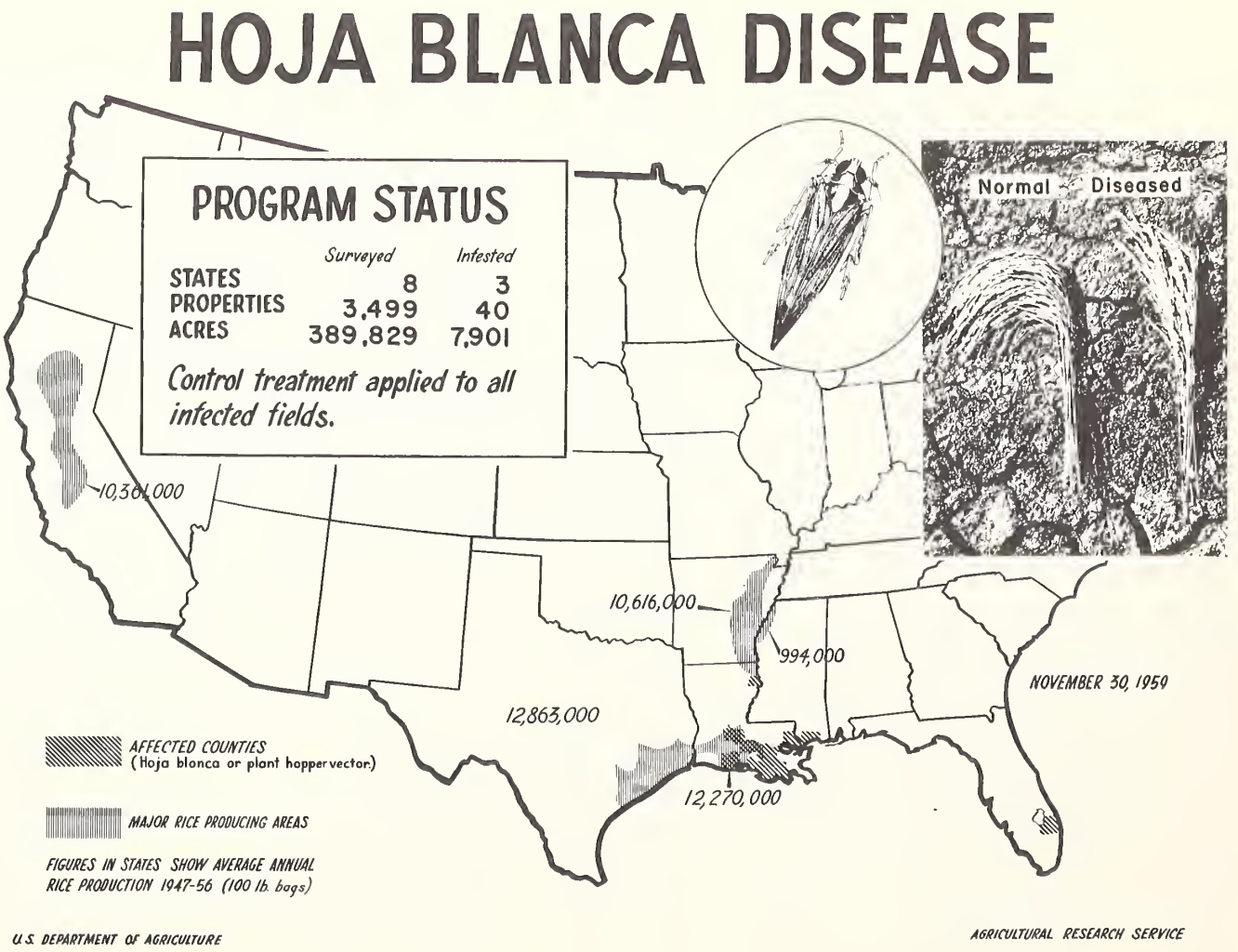

Figure 2.--This illustrated map shows an overall picture of the current status of hoja blanca disease in the United States and the survey program. The adult insect vector is pictured; also panicles from normal rice plants laden with grain in contrast with panicles from stunted, unproductive rice plants damaged by the disease.

Outside of Louisiana, the 1959 survey program detected no sign of hoja blanca in the major commercial rice-growing areas, but the disease was found in Florida and in Mississippi, near former outbreaks.

After this big, systematic survey, 1959 closed with the total record of States, properties, and areas searched since 1957 shown in the "program status" box in figure 2.

In 1960, a Federal-State survey program was started in February with a search in Florida and Louisiana for any hoppers that might have survived the winter. Surveying for the hopper and the disease will be carried out through the season in rice-growing areas.

WHAT RICE GROWERS CAN DO

Anyone who plants rice in a wildlife reserve in a Southerly area is urged to sow only rice varieties known to resist hoja blanca.

For commercial rice growers, "watchful waiting" is the main line of preparedness recommended--so long as hoja blanca does not actually threaten their crops.

Growers of short- and medium-grain rice varieties may choose a precautionary shift to short- and medium-grain varieties that are known to combine desirable commercial qualities with hoja blanca resistance. Such varieties are already grown to some extent, and Gulfrose adds a new one.

For growers of long-grain varieties, waiting is preferable to action such as a shift to shorter-grain resistant varieties while there is uncertainty as to how destructive hoja blanca can be in our agricultural conditions. There is a chance that the virus and its insect carrier may not flourish strongly in climates of our rice-growing areas. There is a chance that some natural enemy of the carrier may keep hopper populations from developing heavy damage.

Watchfulness, to be effective, calls for understanding how hoja blanca destroys rice production and being alert for an outbreak. Growers can be in a stronger position if their preparedness includes:

- Knowing what to expect in an emergency outbreak--the eradication measures necessary and follow-up measures. This knowledge in advance is an aid in launching control work quickly.

- Forming some plan for a shift to resistant varieties, if needed on a short- or long-term basis.

- Keeping up with research advances in understanding and fighting hoja blanca that change the situation from a grower's standpoint.

FURTHER HELP IN PROSPECT

Growers can look forward to help in fighting hoja blanca from research in progress and also from some possible approaches that have

been explored only slightly. The prospects, including these latter possibilities, are along the following lines:

- It seems certain that desirable resistant varieties of all types of rice can be bred. Although this takes time it is the preferred defense because it forestalls the need for chemical control and the results are more lasting.

- It seems likely that more effective insecticide treatments can be developed for control or, if possible, eradication of outbreaks of the hoja blanca vector. Insecticidal control is necessary in an interim period until the establishment of resistant plants. Preliminary experiments with a large number of insecticides have been made in Cuba. Further work remains to be done on comparison of chemicals and arriving at safe and effective dosages and times of application of any insecticide found superior, before changes can be expected in methods currently recommended for combatting outbreaks of the hopper in the United States.

- With further knowledge of the hopper S. orizicola's life cycle and habits in the United States, early seeding may prove a practical aid--for temporary use, at least--to lessen a hoja blanca damage risk.

- Control of the disease may be tightened by recognizing and destroying sources of infection now only tentatively suspected. Host plants are one of these suspected sources.

- Some helpful wasp or other natural enemy of the hoja blanca vector in the United States or in Latin America may be found suitable for use as an aid in keeping down hopper populations.